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(54) Disk apparatus capable of continuous display of data using a single recording head

(57) A disk apparatus for reproducing in a preliminarily determined order digital video data recorded in a plurality of areas (31, 32, 33) of an optical disk (17) at different positions with respect to the radial position of the optical disk in a reproduction mode by an optical head (16). The reproduced video data is stored in a buffer memory (14) and encoded by an MPEG decoder (18). The amount of digital video data corresponding to the access time for accessing the recording areas of the

optical disk are reproduced from the optical disk at a speed higher than the bit rate at which the video data is input or output and stored in the buffer memory. The digital video data are continuously read out and reproduced from the buffer memory when the optical head is in the recording areas and accesses between the recording areas.

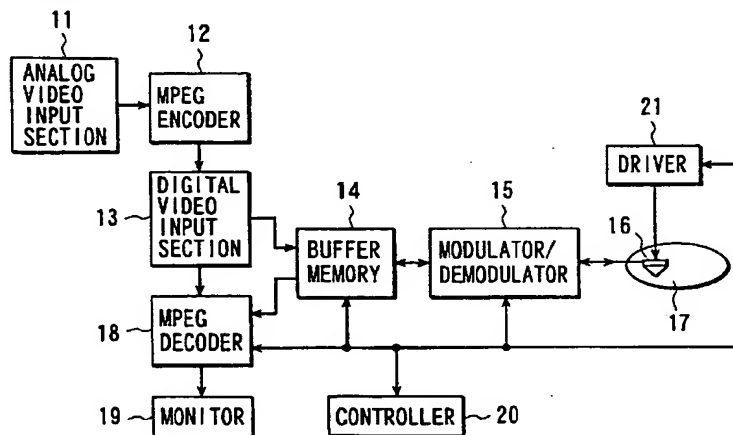


FIG. 1

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Description

The present invention relates to a disk apparatus for recording and reproducing digital continuous data, such as video data, and more particularly, a disk apparatus capable of continuously reproducing digital continuous data recorded in different positions with respect to the radius direction on a recording disk.

Video disk apparatus are being developed for recording and reproducing (writing and reading) digital video data in and from a storage medium, such as an optical disk, using digital video compression, such as the Moving Picture Experts Group (MPEG) method.

According to a conventional video disk apparatus using an optical disk, digital video data compressed by a digital video compressor, such as an MPEG encoder, or digital video data transmitted by broadcast or by CATV (cable television) are temporarily stored in a buffer memory. In the buffer memory, the difference between the bit rate (number of bits to be sent per second) of the digital video data to be inputted and the recording and reproducing speed (write-in and readout speed) of the optical disk (number of bits to be recorded/reproduced per second) is adjusted. In general, the bit rate of the digital video data is slower than the bit rate of the recording and reproducing speed of the optical disk.

As an example of the application of such a video disk apparatus, a plurality of digital video data is recorded in different positions with respect to the radial direction of an optical disk and is reproduced in an optional order. For example, a digital video D1 starting from a radius R1 position, a digital video D3 at a radius R3 position, and a digital video D2 at a radius R2 position are to be reproduced in this order. Herein, $R1 < R2, R3$. In this case, after reproducing the digital video starting from the radius R1, an optical head is moved to the radius R3 position so as to reproduce the digital video D3. Then, the optical head is moved to the radius R2 position for reproducing the digital video D2.

Since the video data cannot be reproduced from the optical disk when the optical head accesses the optical disk, at the time of changing the reproduction from the video D1 to the video D3, or from the video D3 to the video D2, the video is interrupted. That is, the videos cannot be reproduced continuously. In order to solve this problem, a technology has been proposed where two optical heads are provided in a laser disk apparatus, and the like so that one is positioned at a radius position of a currently reproduced video, and the other one positioned at a radius position of a subsequently reproduced video. By switching the heads at the time of changing the videos, the reproduction incapability because of the access can be eliminated so as to enable the continuous video reproduction. However, this method has a major setback in that using two optical heads raises the cost.

An object of the present invention is to provide a

video disk apparatus capable of continuously reproducing a plurality of digital continuous data, such as video data, stored in areas of different positions with respect to the radial direction of the recording medium without interruption using one recording and reproducing head.

The present invention provides a disk apparatus comprising a continuous data input and output section for inputting and outputting continuous data at a first bit rate. The disk apparatus also comprises a recording and reproducing section for selectively recording and reproducing the continuous data in and from a disk-like recording medium at a second bit rate higher than the first bit rate. The disk apparatus further comprises a buffer memory coupled between the continuous data input and output section and the recording and reproducing section for temporarily storing the continuous data to compensate the bit rate difference between the continuous data input and output section and the recording and reproduction section. Also, the disk apparatus comprises a control section for controlling the recording and reproducing section to successively reproduce in a predetermined order continuous data stored in a plurality of areas in the recording medium at different positions with respect to a radial direction of the recording medium. The control section controls the recording and reproducing section and the buffer memory to reproduce digital continuous data for a time more than an access time for accessing the plurality of areas from the recording medium at the second bit rate in the data input and output section and store such data in the buffer memory, and continuously read out the continuous data stored in the buffer memory to the input and output section during the reproduction operation and the access time of the recording and reproducing section.

According to the present invention, a plurality of digital continuous data, such as video data stored in areas in different positions with respect to the radial direction of the recording medium, can be reproduced continuously with one recording and reproducing head without interruption.

In a disk apparatus of the present invention, digital continuous data recorded in a recording medium are reproduced at a speed higher than the bit rate of the digital continuous data for storage in a buffer memory, and the digital continuous data are read out from the buffer memory by the bit rate of the digital continuous data so as to reproduce the continuous information such as the video.

Since the reproducing speed from the recording medium is higher than the bit rate of the digital continuous data, there is a speed difference between the speed for storing the digital continuous data in the buffer memory and the speed for reading the digital continuous data from the buffer rate so that the digital continuous data are accumulated in the buffer memory. When the capacity of the buffer memory becomes full, the reproduction from the recording medium is temporarily inter-

rupted. During the period, the digital continuous data are read out at the bit rate from the buffer memory so as to reproduce continuous information such as a video.

When the amount of digital continuous data recorded in the buffer memory is reduced to an appropriate value, the reproduction from the recording medium is resumed. Therefore, the digital continuous data is intermittently reproduced from the recording medium so that the digital continuous data are read out continuously from the buffer memory.

If the pause period of the reproduction from the recording medium is set at a period longer than the average access time of the recording and reproducing head, the recording and reproducing head can be moved to an area at an optional different position with respect to the radial direction of the recording medium utilizing the pause period so as to reproduce the other digital continuous data recorded in the area. During the access, the digital continuous data recorded in the area at the radial position of the recording medium where the recording and reproducing head was placed before moving are read out from the buffer memory. Subsequently, the digital continuous data are reproduced from the recording medium at the position where the recording and reproducing head is placed after moving, stored in the buffer memory, and read out from the buffer memory at the bit rate of the digital continuous data.

Accordingly, since the digital continuous data are read out and reproduced from the buffer memory even when the recording and reproducing head is moving, the digital continuous data recorded in areas of different positions with respect to the radius direction of the recording medium can be reproduced without interruption.

A memory capacity for a buffer memory in the present invention can be defined as $A \cdot S$ bits or more, where the bit rate of the digital continuous data is A (bps), and the maximum access time to the recording medium (seeking time for a recording and reproducing head to move from the innermost periphery of the recording medium to the outermost periphery plus time for the recording medium to make a rotation) is S second. By providing a buffer memory with such capacity, an amount of digital continuous data corresponding to the access time of the recording and reproducing head can be accumulated preliminarily in the buffer memory utilizing the difference between the reproducing speed at which the digital continuous data is reproduced from the recording medium and the bit rate of the digital continuous data.

When re-seeking due to an unsuccessful seeking is performed, the memory capacity of the buffer memory can be set at $A \cdot S \cdot (N+1)$ bits or more, where the bit rate of the digital continuous data is A (bps), and the number of the seeking retrials is N .

In a disk apparatus having a function for automatically replacing the recording medium, the memory capacity of the buffer memory can be set at $A \cdot S$ bits or

more, where the sum of the maximum time for replacing the recording medium and the maximum access time to the recording medium (seeking time for a recording and reproducing head to move from the innermost periphery of the recording medium to the outermost periphery plus time for the recording medium to make a turn) is S second, and the bit rate of the digital continuous data is A (bps). Accordingly, since the digital continuous data for the replacement time of the medium and the access time to the medium can be stored preliminarily in the buffer memory and the buffer memory can be read out during the time, a plurality of digital continuous data in areas of different optional positions with respect to the radial direction of a plurality of recording mediums can be reproduced without interruption.

When unsuccessful seeking and unsuccessful replacement of the recording medium occur, and the seeking and replacing are retried, the memory capacity of the buffer memory can be set at $A \cdot S1 \cdot (N1+1) + A \cdot S2 \cdot (N2+1)$ bits or more, where the maximum time for replacing the recording medium is $S1$ second, the number of the retrials at the time of an unsuccessful replacement of the recording medium is $N1$, the maximum access time to the recording medium (seeking time for a recording and reproducing head to move from the innermost periphery of the recording medium to the outermost periphery plus time for the recording medium to make a turn) is $S2$ second, the number of the retrials at the time of an unsuccessful seeking is $N2$, and the bit rate of the digital continuous data is A (bps).

Furthermore, in the present invention, at the time of editing digital continuous data recorded in an optional area from a plurality of areas in different positions with respect to the radial direction of a recording medium so as to be recorded in the recording medium as one digital continuous data, the editing efficiency can be improved by controlling the digital continuous data, which can be anticipated to be the reproduced continuous data after editing, to be reproduced continuously before editing, since the editing operation can be confirmed beforehand.

The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which;

FIG. 1 is a block diagram of a video disk apparatus according to an embodiment of the present invention;

FIG. 2 is a diagram showing recording areas on an optical disk for storing digital video data according to an embodiment of the present invention;

FIG. 3 is a flowchart illustrating the recording operation of the video disk apparatus shown in FIG. 1;

FIG. 4 is a graph showing the change of the quantity of video data in the buffer memory of the video disk apparatus of FIG. 1;

FIGS. 5A to 5F are charts showing the content change of the video data in the buffer memory of

the video disk apparatus of FIG. 1;

FIG. 6 is a flowchart showing the reproducing operation of the video disk apparatus shown in FIG. 1;

FIG. 7 is a block diagram of a video disk player according to another embodiment of the present invention; and

FIG. 8 is a block diagram of an audio disk apparatus according to yet another embodiment of the present invention.

FIG. 1 is a block diagram illustrating a video disk apparatus according to one embodiment of the present invention. A video disk apparatus shown in FIG. 1 comprises an analog video input section 11, a digital video data compressor 12 (such as an MPEG encoder), a digital video input section 13, a buffer memory 14, a modulator/demodulator 15, an optical head 16, a recordable and reproducible medium 17, a digital video data decompressor 18 (such as an MPEG decoder), a monitor 19 for displaying a video, a driver 21 for driving the optical head 16, and a controller 20. The buffer memory 14 comprises a memory capable of reading and writing data at the same time, for example, a dual port memory. The recordable and reproducible medium 17 may be, for example, an optical disk, a phase change recording medium, or a magneto-optical recording medium. The optical head 16 may be, for example, a conventional optical head comprising a semiconductor laser, an objective lens, an image sensor, and the like.

The operation of the video disk apparatus according to this embodiment of the present invention is described.

In an illustrative example of the present invention, and in the description hereinafter, digital video data are outputted from the MPEG encoder 12 or the digital video input section 13 at the bit rate of 4 Mbps. The following description describes the processing of digital video data as an illustrative example. However, the data may be analog, and is not limited to video data. For example, the data may be audio.

FIG. 2 is a diagram illustrating recording areas of the optical disk 17 according to an embodiment of the present invention. The optical disk 17 includes a plurality of recording areas 31, 32, and 33. Data of a digital video A are recorded (written) in the recording area 31; data of a digital video C are recorded in the recording area 32, and data of a digital video B are recorded in the recording area 33 in the optical disk 17. Digital video data are recorded in the optical disk 17 at a speed of 8 Mbps, for example, by a constant linear velocity method, and reproduced from the optical disk 17 at the same speed. The maximum access time (seeking time for the optical head 16 to move from the innermost periphery to the outermost periphery of the optical disk 17 plus the time for the optical disk 17 to make a rotation thereof) is 0.25 second, for example. The memory capacity of the buffer memory 14 is 4 M bits, for example.

In the following operation, the recording and repro-

duction operation of the optical disk 17 by the optical head 16, the writing/reading operation of the buffer memory 14, and the like, are controlled by the controller 20.

FIG. 3 is a flowchart illustrating the recording operation for recording the digital video data.

It is determined whether an input video signal is an analog signal, such as a NTSC signal (ST1). When the input video signal is the analog signal, the analog video signal is inputted by the analog video input section 11 to the MPEG encoder 12 (ST2), and subjected to an analog-to-digital conversion and a compression processing (ST3) by the MPEG encoder 12. The digital video signal from the MPEG encoder 12 is input to the digital video input section 13 (ST4).

On the other hand, already compressed digital video data (a "no" response at step ST1), supplied from a CATV, a satellite broadcast, and the like, are inputted directly to the digital video input section 13. The compressed digital video signal is applied to the buffer memory 14 (ST4), and stored therein (ST5).

In step ST6, it is determined whether the data stored in the buffer memory is not more than a given capacity. If the determination at step ST6 is YES, the write operation is interrupted during a predetermined time interval (ST9) and the operation returns to step ST6. If the determination at step ST6 is NO, the digital video data inputted from the digital video input section 13 are written in the buffer memory 14 at the speed of, for example, 4 Mbps. Since the speed of recording the digital video data in the optical disk 17 via the optical head 16 (8 Mbps) is higher than the bit rate of the compressed digital video data supplied from the MPEG encoder 12 (4 Mbps), the digital video data inputted from the digital video input section 13 are temporarily stored in the buffer memory 14. When the digital video data of an appropriate capacity for storing in the optical disk 17 (such as a capacity for 1 sector or 1 track of the optical disk 17) is stored in the buffer memory 14, the digital video data are read out from the buffer memory 14 at the speed of 8 Mbps (ST7). That is, the controller 20 writes the digital video data from the video input section 13 in the buffer memory 14 at the speed of 4 Mbps. When the video data for 1 sector or 1 track is written in the buffer memory 14, the digital video data is read out from the buffer memory 14 at the speed of 8 Mbps.

The digital video data read out from the buffer memory 14 are applied to the modulator/demodulator 15 and modulated to produce a signal appropriate for recording. The signal is inputted to the optical head 16 and recorded in the optical disk 17 by the optical head 16 (ST8). The digital video data inputted from the digital video input section 13 are stored in the buffer memory 14 at the speed of 4 Mbps even during the recording period during which the digital video data is recorded in the optical disk 17 by the optical head 16.

In case of reproducing data of the video A recorded in the recording area 1 of the optical disk 17, the control-

ler 20 sets the apparatus at a reproduction mode and commands the optical head 16 to move to the starting point of the recording area 31 of the optical disk 17 in the radial direction in view of the header information of the optical disk 17. When the optical head 16 reaches the starting point of the recording area 31, the optical head 16 reads out the digital video data from the optical disk 17 at the rate of 8 Mbps. The read out digital video data are written in the buffer memory 14 via the modulator/demodulator 15 at the rate of 8 Mbps. Then the digital video data are read out from the buffer memory 14 to the MPEG decoder 18 at the rate of 4 Mbps. The MPEG decoder 18 decompresses the read out digital video data. The decompressed digital video data are sent to the monitor 19 for display.

Operation of continuously reproducing a plurality of digital video data recorded in recording areas of different radius positions on the optical disk 17 without interruption is described referring to FIGS. 4 to 6.

FIG. 4 is a graph showing the quantity of digital video data in the buffer memory 14 at the time of reproducing a plurality of digital video data. Further, the contents of the buffer memory 14 at times in the graph of FIG. 4, t_a , t_b , t_c , t_d , t_e , t_f are described per 1 M bit in FIGS. 5A, 5B, 5C, 5D, 5E, 5F, respectively. FIGS. 5A to 5F are charts showing the content change of the video data in the buffer memory 14. In FIGS. 5A to 5F, one rectangle shows digital video data for 1 M bits. FIG. 6 is a flowchart showing the reproducing operation of the video disk apparatus.

The case of reproducing the data of the digital video A for 3 seconds and then reproducing the data of the digital video B is described as an example. When the optical head 16 is moved to the recording area 31 by the seeking operation (ST21), the data of the digital video A are read out at the speed of 8 Mbps from the recording area 31 (ST22). In this time, it is determined whether the buffer memory 14 is full (ST23). If the determination is YES, the read operation is interrupted during a predetermined time interval (ST28) and the process returns to step ST23. If the determination is NO, the readout data is stored in the buffer memory 14 (ST24), and, at the same time, are read out from the buffer memory 14 at the speed of 4 Mbps and outputted to the MPEG decoder 18 (ST25). Since a speed difference exists between the reading speed from the optical disk 17 and the bit rate of the digital video data, the digital video data of $(8 \text{ Mbps} - 4 \text{ Mbps}) \times 1 \text{ second} = 4 \text{ M bits}$ is stored in the buffer memory 14 at the time t_a after 1 second. This is shown in FIG. 4 and FIG. 5A.

As shown in FIG. 5A, the memory capacity of the buffer memory 14 is filled to 4 M bits, reproduction of the digital video data from the optical disk 17 is stopped until the next time t_b for 0.5 second and returned to the seeking step (ST21). However, since the digital video data stored in the buffer memory 14 are read out at the speed of 4 Mbps and outputted to the MPEG decoder 18 (ST26) during the time $t_a - t_b$, the video A displayed

on the monitor 19 is reproduced continuously (ST27). Since new digital video data are not inputted to the buffer memory 14 during the period, the digital video data in the buffer memory 14 become $4 \text{ M bits} - 4 \text{ Mbps} \times 0.5 \text{ second} = 2 \text{ M bits}$. This is shown in FIG. 4 and FIG. 5B.

For the next 0.5 second in time $t_b - t_c$, the data of the video A are read out from the optical disk 17 at the speed of 8 Mbps and stored in the buffer memory 14. The digital video data stored in the buffer memory 14 for the 0.5 second become $2 \text{ M bits} + (8 \text{ Mbps} - 4 \text{ Mbps}) \times 0.5 \text{ second} = 4 \text{ M bits}$. This is shown in FIG. 4 and FIG. 5C.

The digital video data reproduced from the optical disk 17 during the time 0 to the time t_c are $8 \text{ Mbps} \times (1 \text{ second} + 0.5 \text{ second}) = 12 \text{ M bits}$. Since this is the capacity corresponding to the digital video for 3 seconds, reproduction of the video A data from the optical disk 17 is stopped. Since it takes 0.5 second to reduce the 4 M bits of the digital video A data stored in the buffer memory 14 to 2 M bits, the optical head 16 can access to the starting position of the digital video B data recorded in the recording area 33 during the period. Since the maximum access time is 0.25 second, the operation of the optical disk 17 is stopped for the initial 0.25 second.

In 0.25 second in the next time $t_c - t_d$, the optical head 16 moves from the recording area 31 to the starting position of the digital video B data in the recording area 33. Since the digital video A data stored in the buffer memory 14 are read out at the speed of 4 Mbps and outputted to the MPEG decoder 18 during the period, the video A data displayed on the monitor 19 can be reproduced without interruption. Since new digital video data are not inputted to the buffer memory 14 during the period, the digital video data in the buffer memory 14 becomes $4 \text{ M bits} - 4 \text{ Mbps} \times 0.5 \text{ second} = 2 \text{ M bits}$. This is shown in FIG. 4 and FIG. 5D.

In 0.25 second from the time $t_d - t_e$, the video B data are read out from the optical disk 17. The digital video data stored in the buffer memory 14 in the 0.25 second become $2 \text{ M bits} + (8 \text{ Mbps} - 4 \text{ Mbps}) \times 0.25 \text{ second} = 3 \text{ M bits}$. This is shown in FIG. 4 and FIG. 5E. At the time of t_e , since the digital video A data for $4 \text{ Mbps} \times 0.25 \text{ second} = 1 \text{ M bits}$ are read out from the buffer memory 14 and outputted to the MPEG decoder 18, the digital video B data for $8 \text{ Mbps} \times 0.25 = 2 \text{ M bits}$ are reproduced from the optical disk 17 and stored in the buffer memory 14, the content of the buffer memory 14 becomes, as shown in FIG. 5E, 1 M bits of the digital video A data and 2 M bits of the digital video B data.

For 0.25 second in the time $t_e - t_f$, the video B data are read out from the optical disk 17. The digital video data stored in the buffer memory 14 in the 0.25 second become $3 \text{ M bits} + (8 \text{ Mbps} - 4 \text{ Mbps}) \times 0.25 \text{ second} = 4 \text{ M bits}$. This is shown in FIG. 4 and FIG. 5F. The content of the buffer memory 14 becomes entirely the digital video B data. Thereafter the digital video B data are

read out from the buffer memory 14 and outputted to the MPEG decoder 18 so that the digital video B is indicated on the monitor 19.

During the access of the optical head 16, the digital video A data preliminarily stored in the buffer memory 14 are read out and outputted to the MPEG decoder 18. Since the digital video B data are already stored in the buffer memory 14 at the time all the data of the digital video A in the buffer memory 14 are read out, they can be outputted continuously to the MPEG decoder 18.

Accordingly, the data of the digital video A and the data of the digital video B recorded in the different recording areas with respect to the radius positions of the optical disk 17 can be continuously inputted to the MPEG decoder 18 via the buffer memory 14 to be decoded so that the videos can be displayed on the monitor 19 without interruption between the digital videos A and B.

Also in the case of continuous reproduction of the digital videos A, B, C, or continuous reproduction of the digital videos in a different order C, B, A, it is apparent that continuous reproduction can be achieved similarly, by storing in advance an amount of digital video data corresponding to the access time in the buffer memory 14 so that the digital video data in the buffer memory 14 can be read out during access.

The movement of the optical head 16 from a recording area to another recording area on the optical disk 17, that is, seeking may be unsuccessful for various reasons, such as the inability to read address information recorded in the optical disk 17. In that case, the seeking operation is conducted again with the upper limit of a preliminarily set retrieval number in the video disk apparatus of this embodiment. During the retrieval of the seeking operation, the digital video data is read out from the buffer memory 14.

Herein, if the capacity of the buffer memory 14 is set at $A * S * (N+1)$ bits or more, where the bit rate of the digital video data is A (bps), the maximum access time (the seeking time for moving the optical head 16 from the innermost periphery to the outermost periphery of the optical disk 17 plus the time for rotating the optical disk 17 by one rotation) is S second, and the number of seeking retrials at the time of unsuccessful seeking is N, the digital video data can be read out from the buffer memory 14 even during accessing by storing in advance the amount of digital video data for the access time of the optical head 16 including the seeking retrieval time in the buffer memory 14. As a result, video reproduction can be achieved without interruption of the video. Here, the $A * S$ bits among the $A * S * (N+1)$ bits are for the initial access, and the $A * S * N$ bits are for the retrials.

Although the amount of digital video data corresponding to the maximum access time to the optical disk 17 was referred to as the buffer memory 14 capacity in the explanation above, in the case of adopting a video disk apparatus comprising an automatic disk

changer for automatically changing the optical disk 17, the buffer memory 14 capacity can be set at $A * S2$ bits or more, supposing that the sum of the maximum exchange time of the optical disk 17 (the maximum time for replacing the currently set optical disk by the farthest optical disk for recording and reproduction) and the maximum access time to the optical disk 17 is S2, and the bit rate of the digital video data is A (bps).

According to the configuration, since the amount of digital video data corresponding to the disk replacement time and the access time can be stored preliminarily in the buffer memory 14 so that the digital video data can be read out from the buffer memory 14 during the replacement time of the optical disk 17 and the access time of the optical head 16, even in the case of reproducing digital video data recorded among a plurality of optical disks, the videos can be reproduced without interruption.

In consideration of the retrials at the time of unsuccessful disk replacement and at the time of unsuccessful seeking, the memory capacity of the buffer memory 14 can be $A * S1 * (N1+1) + A * S2 * (N2+1)$ bits or more, supposing that the maximum time for the disk replacement is S1 second, the number of retrials at the time of unsuccessful disk replacement is N1, the maximum access time to the optical head 16 (the seeking time for moving the optical head 16 from the innermost periphery to the outermost periphery of the optical disk 17 plus the time for rotating the optical disk 17 by one rotation) is S2 second, and the number of retrials at the time of unsuccessful seeking is N2. According to the configuration, since digital video data can be read out from the buffer memory 14 even when retrials are conducted for the optical disk replacement and the optical head access, digital video data in a plurality of disks can be reproduced without interruption.

By using the above-mentioned function for continuously reproducing a plurality of videos, editing of videos is improved because the end result can be viewed before changing the video. Specifically, the anticipated edited reproduced video can be reproduced continuously before editing by commanding the optical head 16 to reproduce selected portions of video. At the time of editing, videos recorded in a plurality of areas in different positions with respect to the radial direction in the optical disk 17 are recorded in the same area in the optical disk as one video data. Therefore, since the result of the editing can be confirmed beforehand, the editing efficiency can be improved.

In the above embodiment, the present invention is applied to a recording/reproducing apparatus. However, the present invention can be applied to a video player.

FIG. 7 is a block diagram illustrating a video disk player according to another embodiment of the present invention. In this case, the video player comprises a buffer 14, an optical head 16, a MPEG encoder 18, a monitor 19, a controller 20, a driver 21, and a demodulator 22. The operation of the video player is similar to

the reproducing mode of the video disk apparatus of FIG. 1.

Also, the present invention may be applied to an audio apparatus.

FIG. 8 is a block diagram of an audio disk apparatus according to yet another embodiment of the present invention. The audio disk apparatus comprises a digital audio signal circuit 41, a buffer memory 42, a digital-to-analog (D/A) converter 43, a speaker 44, and a controller 45. In this audio apparatus, the digital audio signal from the digital audio signal circuit 41 is stored in the buffer memory 42 and at the same time, the audio signal stored in the buffer memory 42 is read out to the speaker 44 via the D/A converter 43.

The digital audio signal circuit 41 and the buffer memory 42 are controlled by the controller 45 for controlling the write-in and readout timings of the buffer memory 42.

According to the above audio apparatus, even if the audio signal from the digital audio circuit 41 is interrupted during a seek operation, since the audio signal read out from the buffer memory 42 is supplied to the speaker 44 via the D/A converter 43, the speaker 44 can continuously output an audio sound. In other words, the present invention can be applied to apparatuses for recording and/or reproducing data continuously in time, e.g., continuous data such as video data and audio data.

Although embodiments with an optical disk as the recording medium have been described, other apparatus using a disk type recording medium for recording and reproducing data with a recording and reproducing head can be used. Examples thereof include a magnetic disk apparatus (hard disk apparatus) and a floppy disk apparatus.

As heretofore explained, according to the present invention, an amount of digital video data corresponding to the access time of the recording and reproducing head or more are preliminarily reproduced from the recording medium and stored in the buffer memory utilizing the difference between the reproducing speed of the recording medium and the bit rate of the digital video data. The digital video data stored in the buffer memory is read out during the access for seeking digital video data recorded in areas of different positions with respect to the radius direction of the disk in a preliminarily determined order, so that the digital video can be reproduced during the access. As a result, the digital videos recorded in different areas of optional positions with respect to the radius direction in the disk can be reproduced without interruption using one recording and reproducing head.

Claims

1. A disk apparatus characterized by comprising:

a data input and output section (11, 12, 18, 19)

for inputting and outputting data at a first bit rate;

a recording and reproducing section (15, 16) for selectively recording and reproducing the data in and from a disk-like recording medium at a second bit rate higher than the first bit rate; a buffer memory (14) coupled between the data input and output section and said recording and reproducing section for temporarily storing said data for compensating the bit rate difference between said data input and output section and said recording and reproduction section; and

a control section (20) for controlling said recording and reproducing section to successively reproduce in a predetermined order data stored in a plurality of areas in said recording medium at different positions with respect to a radial direction of said recording medium, said control section controlling said recording and reproducing section and said buffer memory to reproduce digital data for a time more than an access time to access said plurality of areas from said recording medium at the second bit rate in said data input and output section and store such data in said buffer memory, and continuously read out the data stored in said buffer memory to said input and output section during the reproduction operation and said access time of said recording and reproducing section.

2. The disk apparatus according to claim 1, characterized in that said control section (20) controls said recording and reproducing section (15, 16) and said buffer memory (14) to stop the reproduction of the data at said recording and reproducing section when the data are stored in the buffer memory to the memory capacity, but continuously reads out the data from said buffer memory to said input and output section.
3. The disk apparatus according to claim 1, characterized in that said data input and output section comprises an analog input section (11) for inputting analog data, an encoder (12) for analog-to-digital converting and data-compressing the analog data to obtain compressed digital data, and a decoder for decoding the data read out from said buffer memory.
4. The disk apparatus according to claim 3, characterized by further comprising a monitor (19) for indicating the continuous data decoded by the decoder.
5. The disk apparatus according to claim 1, characterized in that said recording and reproducing section has an optical head (16) for recording the data read out from said buffer memory in the recording

medium and reproducing the data recorded in said recording medium.

6. A disk apparatus characterized by comprising:

a recording and reproducing head (16) for selectively recording and reproducing digital data in a disk-like recording medium;
a buffer memory (14) for temporarily storing said digital data reproduced by said recording and reproducing head; and
a controller (20) coupled to the recording and reproducing head and to the buffer memory for controlling said recording and reproducing head to successively reproduce in a predetermined order the digital data recorded in a plurality of areas of said recording medium at different positions with respect to a radial direction of said recording medium,

wherein said controller (20) controls said recording and reproducing head so that an amount of digital data corresponding to at least an access time for accessing said plurality of areas are reproduced at a speed higher than a bit rate at which the data is input to or output from an external input/output section and stored in said buffer memory, and the digital data stored in said buffer memory are continuously read out to said external input/output section when said recording and reproducing head is within said areas and during said access time.

7. The disk apparatus according to claim 6, characterized in that said buffer memory (14) has a memory capacity of $A * S$ bits or more, where the bit rate of said digital data is A and the maximum access time to said recording medium which is seeking time for moving said recording and reproducing head from the innermost periphery of said recording medium to the outermost periphery plus time for rotating said recording medium by one rotation is S .

8. The disk apparatus according to claim 6, characterized in that said buffer memory (14) has a memory capacity of $A * S * (N+1)$ bits or more, where the bit rate of said digital data is A (bps), the maximum access time to the recording medium which is a seeking time for moving said recording and reproducing head from the innermost periphery of said recording medium to the outermost periphery plus time for rotating said recording medium by one rotation is S second, and the number of the seeking retrials is N .

9. The disk apparatus according to claim 6, characterized in that said buffer memory (14) has a function of automatically changing said recording medium,

and a memory capacity of $A * S$ bits or more, where the sum of the maximum time for replacing said recording medium and said maximum access time to said recording medium which is a seeking time for moving a recording and reproducing head from the innermost periphery of said recording medium to the outermost periphery plus time for rotating said recording medium by one rotation is S second, and the bit rate of said digital data is A (bps).

10. The disk apparatus according to claim 6, characterized in that said buffer memory (14) has a function of automatically changing said recording medium, and a memory capacity of $A * S1 * (N1+1) + A * S2 * (N2+1)$ bits or more, where the maximum time for replacing said recording medium is $S1$ second, the number of the retrials at the time of an unsuccessful replacement of said recording medium is $N1$, the maximum access time to said recording medium which is seeking time for moving said recording and reproducing head from the innermost periphery of said recording medium to the outermost periphery plus time for rotating the recording medium by one rotation is $S2$ second, the number of the retrials at the time of an unsuccessful seeking is $N2$, and the bit rate of said digital data is A (bps).

11. The disk apparatus according to claim 6, characterized in that said control section (14) controls said recording and reproducing head and said buffer memory to record at the time of editing in an optional area among the plurality of areas in different radius positions of the recording medium data that is representative of digital data anticipated to be the reproduced data after editing, the anticipated digital data being continuously reproduced before editing.

12. The disk apparatus according to claim 6, characterized in that said recording and reproducing head (16) records and reproduces video data as the continuous data in and from said recording medium.

13. A disk apparatus characterized by comprising:

a buffer memory (14) having a first input for receiving data at a first bit rate, having a second input for receiving data at a second bit rate, having a first output for providing data stored therein at a third bit rate and having a second output for providing data stored therein at a fourth data rate, the buffer memory temporarily storing data therein to compensate both for the difference of the first and third bit rates and for the difference of the second and fourth bit rates;
a recording and reproducing head (16) coupled to said second input and said first output of said

buffer memory and selectively movable relative to a disk-shaped recording medium to different positions in a radial direction of said recording medium for accessing said recording medium and for selectively recording data at the third bit rate on said recording medium and reproducing data at the second bit rate from said recording medium;

a controller (20) coupled to the buffer memory and the recording and reproducing head for controlling said recording and reproducing head to successively move to selected ones of a plurality of areas in said recording medium at said different positions of said recording medium, said controller controlling said recording and reproducing head to record data from said buffer memory on said recording medium and apply data reproduced from the recording medium to the buffer memory, and controlling said buffer memory to continuously read out the data stored therein during the reproduction and accessing operation of the recording and reproducing head.

14. The disk apparatus according to claim 13, characterized in that the third bit rate is faster than the first bit rate, and the second bit rate is faster than the fourth bit rate.

15. The disk apparatus of claim 14, characterized in that the third and second bit rates are at least twice as fast as the first and second bit rates, respectively.

16. The disk apparatus according to claim 13, characterized in that said controller (20) controls said recording and reproducing head and said buffer memory (14) to stop reproducing the data by said recording and reproducing head when the continuous data are stored in the buffer memory to a portion of the memory capacity of the buffer memory, and to continuously read out the continuous data from said buffer memory.

17. A disk apparatus for recording and reproducing data on a recording medium (17), the recording medium having a plurality of areas (31, 32, 33) thereon at different positions in a radial direction of the recording medium, the disk apparatus characterized by comprising:

a recording and reproducing head (16) for selectively recording and reproducing digital data in the recording medium and selectively moveable to access for recording and reproducing data from the plurality of areas of the recording medium;

a buffer memory (14) coupled to the recording

and reproducing head for temporarily storing said digital data reproduced by said recording and reproducing head or received from an external source; and

a controller (20) coupled to the recording and reproducing head and to the buffer memory for controlling said recording and reproducing head to selectively move for successively reproducing in a predetermined order the digital data recorded in the plurality of areas of said recording medium having an amount of digital data corresponding to at least an access time for accessing said plurality of areas at a speed higher than a bit rate at which the data is input to or output from an external device and stored in said buffer memory, and for controlling the buffer memory to continuously output the digital data stored therein to the external device when said recording and reproducing head is positioned near said areas and during said accessing.

18. The disk apparatus according to claim 17, characterized in that said buffer memory (14) has a memory capacity determined by the bit rate of said digital data and the access time of moving the recording and reproducing head from an innermost periphery of said recording medium to an outermost periphery plus the time for rotating said recording medium by one rotation.

19. The disk apparatus according to claim 17, characterized in that said buffer memory (14) has a memory capacity determined by the bit rate of said digital data, the maximum access time for moving said recording and reproducing head from an innermost periphery of said recording medium to an outermost periphery plus a time for rotating said recording medium by one rotation, and the number of the seeking retrials.

20. The disk apparatus according to claim 17, characterized in that the disk apparatus is capable of automatically changing said recording medium (17), and the buffer memory (14) has a memory capacity of at least $A * S$ bits, where the sum of the maximum time for replacing said recording medium and said maximum access time to said recording medium which is a seeking time for moving a recording and reproducing head from an innermost periphery of said recording medium to an outermost periphery plus time for rotating said recording medium by one rotation is S second, and the bit rate of said digital data is A (bps).

21. The disk apparatus according to claim 20, characterized in that said buffer memory (14) has a memory capacity of $A * S_1 * (N_1+1) + A * S_2 * (N_2+1)$

bits or more, where the maximum time for replacing said recording medium is S1 second, the number of the retrials at the time of an unsuccessful replacement of said recording medium is N1, the maximum access time to said recording medium which is seeking time for moving said recording and reproducing head from an innermost periphery of said recording medium to an outermost periphery plus a time for rotating the recording medium by one rotation is S2 second, the number of the retrials at the time of an unsuccessful seeking is N2, and the bit rate of said digital data is A (bps).

22. The disk apparatus according to claim 17, characterized in that said control section (20) controls said recording and reproducing head (16) and said buffer memory (14) so that selected digital data that is anticipated to be post-edited reproduced continuous data are continuously reproduced before editing and, at the time of editing, the selected digital data is recorded in a selected area among the plurality of areas in different radius positions of the recording medium as one digital data.

23. A disk apparatus for reproducing data from a storage medium (17), the storage medium having a plurality of areas thereon at different positions in a radial direction of the storage medium, the disk apparatus characterized by comprising:

a reproducing head (16) for selectively reproducing digital data from the storage medium and selectively moveable for accessing the plurality of areas of the storage medium for reproducing the digital data from the accessed area; a buffer memory (14) coupled to the reproducing head for temporarily storing said digital data reproduced by said reproducing head; and a controller (20) coupled to the reproducing head and to the buffer memory for controlling said reproducing head to selectively move for successively reproducing in a selected order the digital data recorded in the plurality of areas of said storage medium having an amount of digital data corresponding to at least an access time for accessing said plurality of areas at a speed higher than a bit rate at which the continuous data is provided to an external device and stored in said buffer memory, and for controlling the buffer memory to continuously output the digital data stored therein to the external device when said reproducing head is positioned near said areas and during said accessing.

24. An apparatus for recording data on a recording medium (17), the recording medium having a plurality of areas thereon at different positions in a

radial direction of the recording medium, the disk apparatus characterized by comprising:

a buffer memory (14) for temporarily storing data received from an external source for recording on the recording medium; and a recording head (16) coupled to the buffer memory for selectively recording the data in the recording medium and selectively moveable to access the plurality of areas of the recording medium for recording the data; a controller (20) coupled to the recording head and to the buffer memory for controlling said recording head to selectively move for successively recording in a selected order the data in the plurality of areas of said recording medium having an amount of data corresponding to at least an access time for accessing said plurality of areas at a speed higher than a bit rate at which the data is received from the external source and stored in said buffer memory, and for controlling the buffer memory to output the data stored therein to the recording head when said recording head is positioned near said areas.

25. A disk apparatus characterized by comprising:

a buffer memory (14) having a first input for receiving data at a first bit rate, having a second input for receiving data at a second bit rate from an external recording and reproducing head, having a first output for providing data stored therein at a third bit rate to the external recording and reproducing head and having a second output for providing data stored therein at a fourth data rate, the buffer memory temporarily storing data therein to compensate between the difference of the first and third bit rates and the difference of the second and fourth bit rates; and

a controller (20) coupled to the buffer memory and having an output for providing a control signal to said external recording and reproducing head to successively move said external recording and reproducing head to selected ones of a plurality of areas in a recording medium at different positions in a radial direction of said recording medium for accessing said recording medium and for selectively recording data from the buffer memory at the third bit rate on said recording medium and reproducing data at the second bit rate from said recording medium for application to the buffer memory, and controlling said buffer memory to continuously read out the data stored therein during the reproduction and accessing operation of the recording and

reproducing head.

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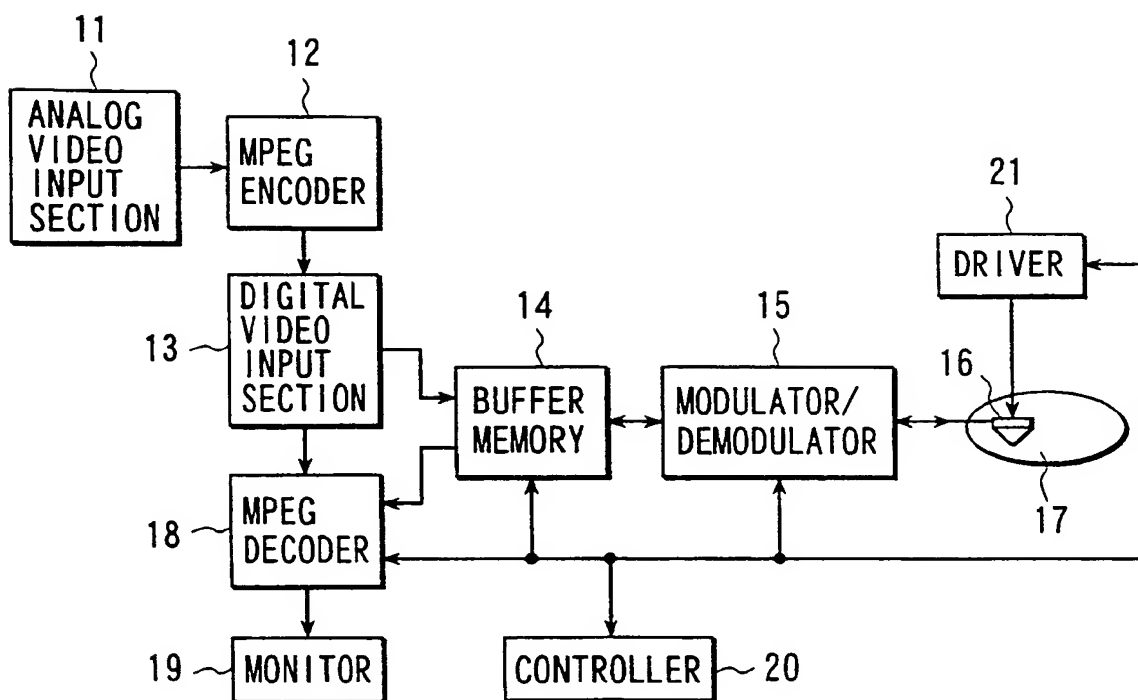


FIG. 1

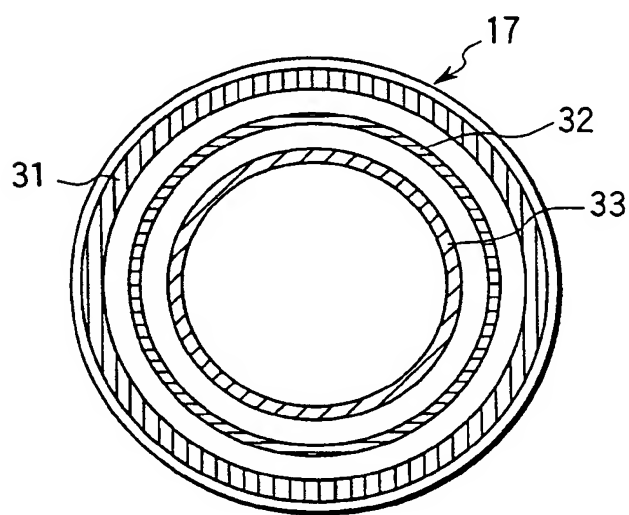


FIG. 2

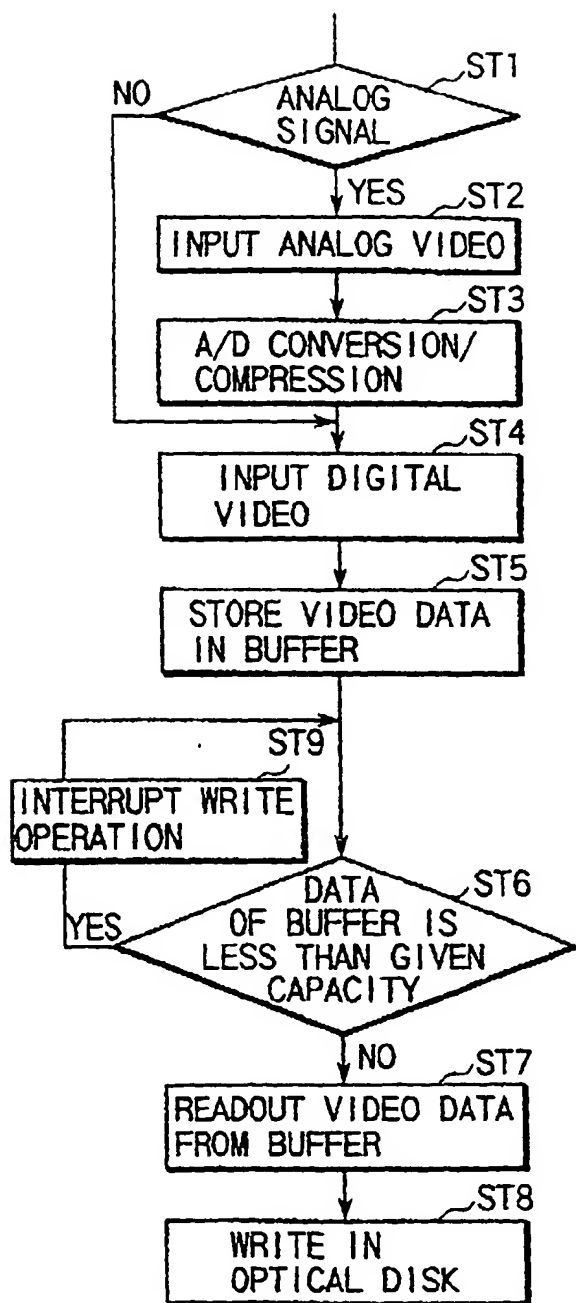


FIG. 3

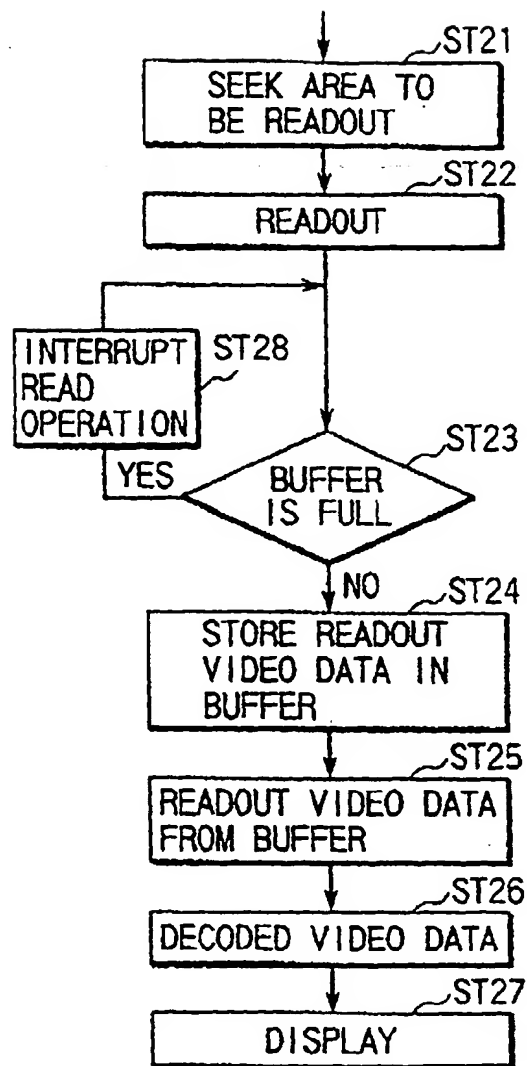


FIG. 6

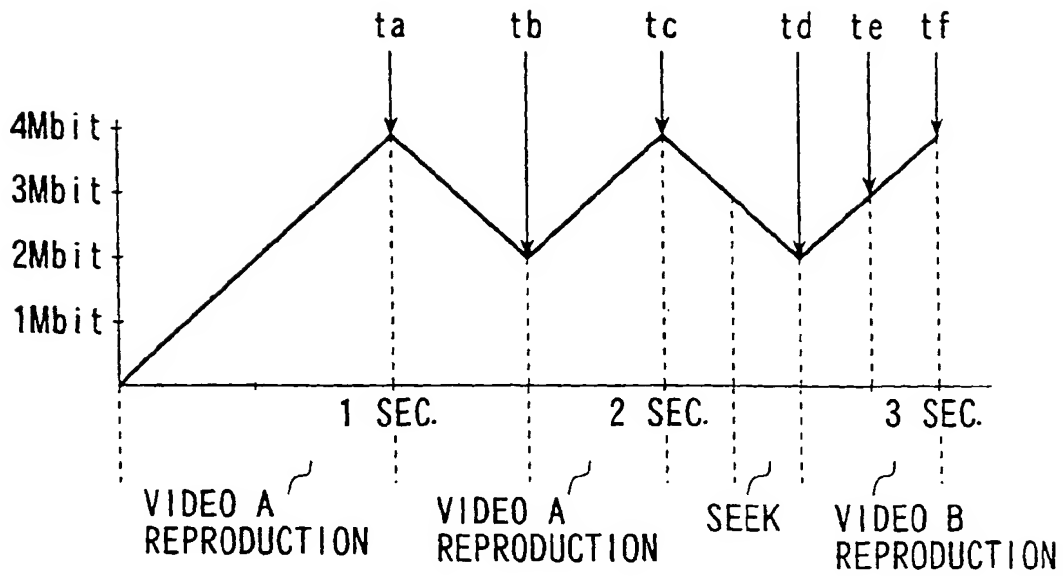


FIG. 4

FIG. 5A



FIG. 5B



FIG. 5C

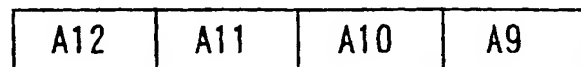


FIG. 5D



FIG. 5E

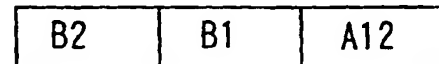


FIG. 5F



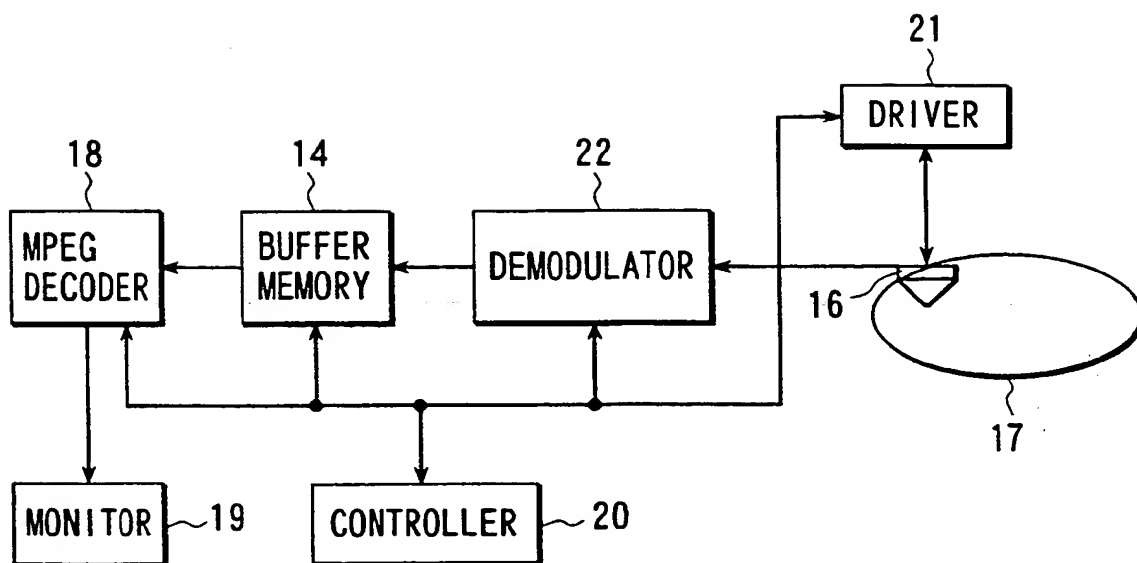


FIG. 7

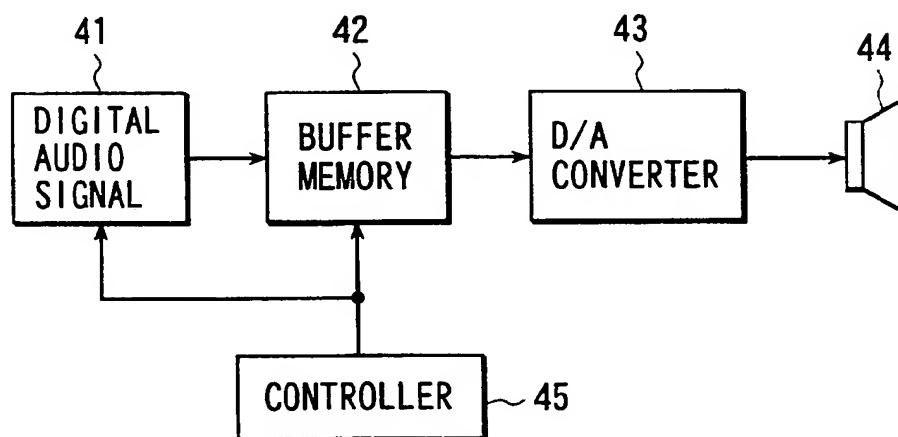


FIG. 8

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